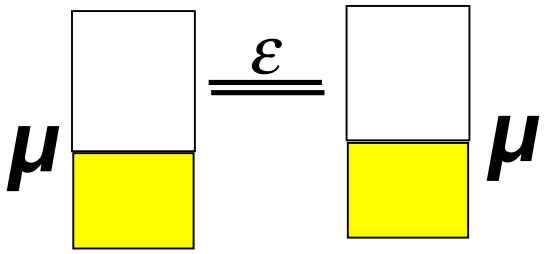
ECE 659 Spring '09 Weeks 14-15: Correlated Transport

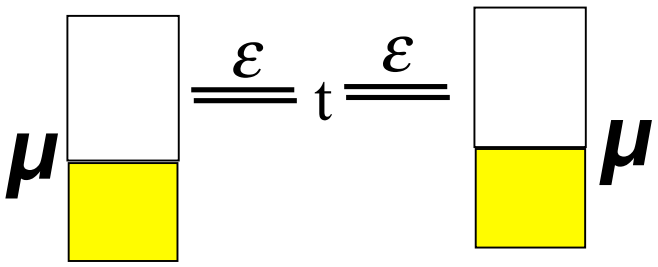
HW#8: Due Wednesday April 29, 2009 in class

Law of Equilibrium: $\rho = \frac{1}{Z}\exp\left(-(H-\mu N)/k_B T\right)$, $\langle N \rangle = Trace(\rho N)$

1. Consider a quantum dot with two spin-degenerate levels with energy ε = 0 and interaction energy U, in equilibrium with a reservoir with an electrochemical potential μ. The coupling to the reservoir is weak enough that the broadening is negligible. Plot the average number of electrons $\langle N \rangle$ in the channel, as μ is varied over the range -25 < $\mu/k_B T$ < +25, if (a) U/$k_B T$ = 1e-3 , (b) $U/k_B T$ = 20.



2. Repeat Problem 1 for two coupled quantum dots each with two spin-degenerate levels, such that the one-electron Hamiltonian, h, having an intra-dot interaction energy U and zero inter-dot interaction energy. Assume energy ε = 0 and t/$k_B T$ =5.



$$h = \begin{array}{c} \begin{matrix} a & b & \bar{a} & \bar{b} \end{matrix} \\ \begin{bmatrix} \varepsilon & t & 0 & 0 \\ t & \varepsilon & 0 & 0 \\ 0 & 0 & \varepsilon & t \\ 0 & 0 & t & \varepsilon \end{bmatrix} \end{array}$$

Explain analytically the values of μ at which the transitions take place from N = 0 to 1 to 2 to 3 and finally to 4.

Please remember to turn in your MATLAB codes for both problems.